GLENS FALLS FEEDER: SLUICE HAER No. NY-200
Beginning 350 feet SE of the junction of Pine Street and Burgoyne Avenue, heading 600 feet in an E-SE direction along S side of the Glens Falls Feeder between Locks 10 and 6.
Hudson Falls ~~City~~
Washington County
New York

HAER
NY
58-HUFA,
2-

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
Northeast Field Area
Chesapeake/Allegheny System Support Office
National Park Service
U.S. Custom House
200 Chestnut Street
Philadelphia, PA 19106

HAER
NY
58-HUFA,
2-

HISTORIC AMERICAN ENGINEERING RECORD

GLENS FALLS FEEDER: SLUICE HAER No. NY-200

Location: Beginning 350 feet southeast of the junction of Pine Street and Burgoyne Avenue, heading 600 feet in an east-southeasterly direction along the south side of the Glens Falls Feeder, between Locks 10 and 6.
Hudson Falls City
Washington County
New York

UTM: 18.615900.4794500
Quad: USGS Hudson Falls, N.Y.

Date of Construction: 1838-9. Rebuilt 1841-2, 1858-9, 1875-6, 1889-90, c.1903, 1912.

Present Owner: New York State Department of Transportation

Present Use: Unused, partially collapsed in the early 1970's; feeder flow presently rerouted entirely through locks.

Significance: The Glens Falls Feeder: Sluice is considered significant for two reasons. The central, stone arch component of this resource represents a unique engineering structure, relative to other lock bypass structures built for canals in New York State, both due to absolute length and construction technology. As a more inclusive group of features, which together demonstrate evolution of the sluice design and technology over time, the Glens Falls Feeder: Sluice is also significant by association with the Glens Falls Feeder, which in contributing significantly to the economic development of Glens Falls and the surrounding upper Hudson region, has been considered eligible for the National Register of Historic Places.

Project Information: This documentation was conducted in July-September 1988, according to an agreement between the New York State Department of Transportation and the New York State Office of Parks, Recreation and Historic Preservation. The work was undertaken as the cultural resource survey for the New York State Department of Transportation PIN 1940.77.101, in compliance with the Memorandum of Agreement between the New York State Museum and the NYSDOT.

Mark S. LoRusso
Cultural Resource Survey Program
New York Stste Museum
Albany, N.Y.

Perhaps contrary to its simple function, the Glens Falls Feeder: Sluice embodies a relatively complex history. Constructed as a bypass for Locks 6-10 on the Glens Falls Feeder, the sluice was designed to help maintain the flow of water to the summit of the Champlain Canal, particularly while the associated locks were in use, or under repair (Locks 6-10 comprised a combination lock known as the "five combined"). Probably due to its comparatively great length and vertical drop, and correspondingly high levels of water turbulence and velocity, the sluice around the five combined required more attention than other sluices on the Feeder. After its initial construction in 1838-9, the sluice around the five combined would undergo six major rebuilding episodes, as well as numerous minor repairs in the intervening periods. Each reconstruction advanced the use of a new design and/or combination of materials, in theory, to provide a more efficient and enduring structure than the previous one. As discussed below, components of at least four of these structures are extant.

Consideration of the Glens Falls Feeder: Sluice must begin with an initial look at the Glens Falls Feeder itself. The purpose of the Glens Falls Feeder, as proposed in 1820, was to supply water to the Champlain Canal at its summit level. The Feeder was designed to divert flow from the Hudson River, at a location west of Glens Falls, over a seven-mile course to the Champlain Canal at Fort Edward. As built in 1823-29, following some deliberation over its feasibility, the Glens Falls Feeder integrated a second, and perhaps equally important function; to provide a navigational route into the upper Hudson region, an area recognized by the canal commissioners as a potentially important source of timber, quarry stone and other raw materials. Proposed use of the Feeder for navigation required that a total of thirteen locks be built over its course, in order to ascend the 130-foot terrace rising west from Fort Edward. Ten of the thirteen were within the first one-half mile west from the Champlain Canal, including the five combined, located just north of the Fort Edward-Kingsbury town line (see NY-200-21, 1834 Holmes Hutchinson map of the five combined). (1)

The dual function of the Glens Falls Feeder would pose an immediate problem; the routine practice of channeling water downstream through the locks both restricted the passage of water and caused excess wear on, and failure of the original, wooden lock structures.(2) In 1834, Erie Canal engineer Holmes Hutchinson was enlisted by the New York State canal commission to evaluate and make recommendations for overall improvement of the Glens Falls Feeder. (3) Part of Hutchinson's evaluation addressed the above problem:

> The practice of feeding through the paddle-gates as will readily be perceived, is attended with great inconvenience, extra labor and detention of boats. Besides the injury to the small gates by wear, the accumulation of floodwood and other obstructions in the breast of the lock, causes a delay in working the lock gates, and sometimes is the cause of great injury to the paddle-gates. Added to all this, there is a total suspension of the passage of the water while the boats are going through the locks. (4)

To relieve this situation, Hutchinson proposed that the locks be reconstructed of "good hammered limestone having large and even beds...well laid in cement...," and that **bypass sluices be built around the locks** both "to pass the water for supply of the summit level and (to) connect and regulate the quantity in the basins between the locks." The sluices were to be constructed with a waste of "fifteen feet in length and six inches below the top water line of the canal having requisite gates (to) keep the water in each pound reach at the required height for navigation." (5) In this statement, Hutchinson referred to the length and height of the sluice runout below each drop in elevation (parallelling that of the locks), and the need for interconnecting chambers (with gates) between the sluices and the locks to allow water passing through the sluice to be drained down into the locks if necessary.

In 1836, legislative passage of the Champlain Canal Act, Chapter 453, Laws of 1836, provided for implementation of the proposals set forth by Hutchinson, or "other appropriate measures in the public interest". (6) Among the features which were implemented, a principal deviation from Hutchinson's plan was the decision by the canal commissioners to preserve the five combined locks (as well as one double lock). According to the canal commissioner's report of 1836,

> A single line of combined locks is, no doubt objectionable, in most situations. The delay occasioned by the necessity of passing one boat through the entire combination, before another, passing in a different direction, can enter; and the much greater quantity of water required for the combination than for single locks, are serious objections, where the amount of navigation is considerable, or where the supply of water is deficient, and more is thereby transmitted to the level below than is wanted. But as these objections do not exist in this instance, and as an important advantage is obtained by the adoption of the combination, in reference to the expense of the work, it was thought expedient that the combinations be retained. (7)

Construction of the first bypass sluices was essentially concurrent with reconstruction of the locks, both completed in 1839. (8) However, the sluice construction was let under a separate contract to Page, Kellogg, Sage and Co., of Albany, N.Y. (9) As indicated in the 1840 canal commissioners report, which already describes the inadequacy of the sluice structures, both new materials and discarded lock timbers were utilized to construct "wooden trunks" of which one was buried in sand and some were uncovered. At the five combined locks, the upper three sections of the sluice apparently reused all, or part of the old lock combine. (10) It is not known whether or not these structures met the specifications for height, length and interconnecting culverts between the sluce and adjacent locks outlined by Hutchinson.

The final account for the Page, Kellogg contract describes the large quantities of new timbers, planks and boards required to build the wooden trunks. The account also details the amounts of excavation, and embankment and masonry needed to provide aupport for the sluice, and presumably to retain the steep, adjacent bank.

Excavation	1685.00	cubic yds.	$ 421.25
Embankment	1175.00	" "	292.75
Masonry	222.58	" "	1335.48
Hemlock timber	5323.00	cubic ft.	1490.44
Hemlock plank & boards	2561.00	board ft.	716.24
Pine plank & boards	7854.00	" "	214.16
Oak plank & boards	238.00	" "	9.52
Caulking	1266.00	lineal ft.	126.60
Total			$4737.54 (11)

In 1840, the report of the canal commissioners states that the sluices for the upper three locks are "much decayed and will not remain standing another year without extensive repairs." The lower two sections had structures "that may last three years." Alternative to the failing wooden sluice structures at the five combined, and at other locks on the Feeder, the 1840 report proposes "**to construct substantial stone arches on timber foundations**; the foundations to be so placed as to be always covered with water. The foundations of the old wooden locks may be used where they are not decayed." (12)

In 1841, under the provisions of Act 111, Laws of 1841, $75,000 was appropriated for enlargement and tightening of the Glens Falls Feeder, in order to improve its supply capacity. The previous inadequacy of the Feeder in this regard had resulted both from its limited sectional area and its greater than 50% leakage rate (principally where the channel croased fissured limestone beds). The Feeder improvements represented the most feasible of three methods proposed by canal engineer Charles A. Olmstead for stabilizing the flow of water to the summit of the Chsmplain Canal; the other methods involved improving an alternate feeder controlled by the Fort Edward dam. (13)

Included among the proposed improvements was reconstruction of the bypass sluices, a contract let in 1841, and completed in 1842. (14) At the five combined locks, the reconstructed sluice would divert water around the Feeder channel by means of a (buried) stone arch culvert. It is this structure which forms the core of the Glens Falls Feeder: Sluice (see GFFS DRAWING-2, site plan; and GFFS DRAWING-3, profile). The standing sections of this 1841-2 sluice, described in the following paragraph, provided much of the data on the function and construction technology of its individual components.

From its (original) head above Lock 10, the stone arch sluice presently consiats of the following: a destroyed section between the Feeder channel and the second drop (NY-200-1, DESTROYED HEAD OF STONE SLUICE), a standing section 65 feet in length including the aecond drop (NY-200-2, 3, VIEWS OF INTERIOR OF SECOND DROP; NY-200-4, STONE SLUICE, TOP OF UPPER STANDING SECTION; NY-200-5, STONE SLUICE, HEAD OF 40-FOOT BREAK), a collapsed section or break, 40 feet in length, sxtending to the third drop (NY-200-5, STONE SLUICE, HEAD OF 40-FOOT BREAK; NY-200-6, STONE SLUICE, BEGINNING OF LOWER STANDING SECTION), a mostly intact section 260 feet in length (comprising the remainder of the buried section), punctuated by small breaks at the fourth drop, and fifteen feet down from the fifth drop (NY-200-8, STONE SLUICE, TOP OF LOWER STANDING SECTION), and the sluice discharge basin, partially infilled, and impacted by subsequent sluice constructions (NY-200-12-16, DISCHARGE BASIN: VIEW NORTHWEST, NORTH SIDEWALL SHOWING JUNCTION, SOUTH SIDEWALL, FOOT OF NORTH SIDEWALL, FLOOR).

As determined from inspection of the described featurea, the stone arch sluice consisted of (probably) five level sections (typically measuring 91 feet in length, 10 feet in width and 4.5 feet in height), connected by (probably) five vaults or "drops" (12 feet x 10.5 feet x 14.6 feet), which provided the descent from 250 to 200 feet paralleling Locka 10-6. ("Probably" ia uaed due to present destruction of the head of the sluice, which presumably included the first drop and connecting section to the second drop). Water exited from the buried section above Lock 7 into an open, stone-lined discharge basin which joined the Feeder channel below Lock 6. There is no evidence that connecting conduits were built between the sluice and the Feeder canal for control of the water level, as discussed, a function proposed by Holmes Hutchinson for the first sluice(a).

Ths foundation of the structure consiated of timber, more specifically of closely-spaced cross beams covered with plank sheathing. This type of construction was common practice for culverts and locka built at the time, structures in which the underlaymsnt would be continually submerged, thereby preserving the timbera. The sluice foundation is presently visible in the second drop (NY-200-2, INTERIOR OF SECOND DROP, FOUNDATION, FOOTWALL AND SIDEWALLS).

The auperstructure was built as a semicircular arch in mortared limeatone, which was procured from nsarby quarries in the town of Kingabury, and floated down the Feeder as needed. (15) Two types of arch masonry were utilized in construction of the sluice, preaently shown at the second and third drops (NY-200-2, 3, INTERIOR OF SECOND DROP; NY-200-7, INTERIOR OF THIRD DROP). The vertical face and aidewalls of the drops consisted of broken ashlar construction, fitting a general canal contract specification for vertical and battered walls (16), and also known as "first class masonry." The arch construction in both the drops and connecting sluice sections consisted of small, regular-sized stone, 12-15 inches in length and several inches in thickness, laid in a single tier at right angles to the face of the arch. Thia type of construction fit a general contract apecification for slope and pavement wall, (17) and could also be called "aecond class masonry."

Croaa-sections of the arch at either end of the 40- foot break clesrly ahow this construction (NY-200-5, STONE SLUICE, HEAD OF 40-FOOT BREAK; NY-200-6 STONE SLUICE, BEGINNING OF LOWER STANDING SECTION). The arches were preaumably built over a wooden form, typically constructed of planks nailed lengthwise over a croasbraced frame. (18)

Although it ia possible that the stone-lined diacharge basin is contemporary with the firat wooden aluice(s) built around the five combined, the use of ashlar construction in the sidewalls suggests that thia atructure was built as the terminus for the more permanent atone arch sluice. Portions of both original sidewalls are extant, consisting of a 20-foot aegment of the south wall (NY-200-14, DISCHARGE BASIN, SOUTH SIDEWALL), and a 140-foot segment of the north wall, beginning respectively, 30 feet and 40 feet down from the headwall. The north wall is bridged to the headwall by later (1889) construction and has partially collapsed near ita terminus (NY-200-13, DISCHARGE BASIN, NORTH SIDEWALL). The headwall of the structure, although mostly buried in the discharge basin, was shown by inspection of the interior of the sluice, to be subtantially intact. The exit gate from the buried section into the diacharge basin used a low opening aupported by a atone lintel, perhaps restricted in size to control the volume and velocity of water entering the baain. The floor of the aluice is mostly silted-in, but reveals evidence of post-1900 sluice reconstruction.

The preaent evidence suggeats that the stone arch sluice was most vulnerable to collapse at the drop sections - three of the four remaining drops have been affected by breaks. This condition may well have been due to higher levela of water turbulence in the dropa, which would have accelerated deterioration of the mortar. It is probable that the arch collapsed typically because of downward slippage of the voisaoirs or arch stones (depicted in Barge Canal photographs of other aluice sections), (19) a type of deterioration characteristic of arches in which the rise is much less than the span (a ratio of 4.5:10 feet in the subject sluice). (20)

Failure of the aluices appears to have commenced at an early date, as indicated in reports of the canal commiasioners, which in 1853 state that aeveral sluices are "in bad condition and will require considerable repair," (21) and in 1857, that "sluices around the locka on the Glens Falls Feeder have been in a precarioua condition for aeveral years. Any further delay in rebuilding them will not only endanger navigation of thia feeder, but all that portion of the Champlain." (22)

The condition of the sluice around the five combined locks may well have been the worst of all Feeder sluicea at this time, perhaps due to the comparatively steep overall drop, and conaequently higher turbulence and water velocity at this location. In June 1858, under Chapter 210, Laws of 1858, a contract for reconstruction of only the sluice around the five combined waa let to Joseph McFarland of Sandy Hill (Hudson Falls). That the sluice built by McFarland was a wooden structure (trunk) built upon the 1841 stone (arch) sluice, is shown in an account of ita failure ten years hence, on July 3,

1868: "The sluice gave way, and the water passing under the foundation at the head, carried out the greater portion of the arch beneath the trunk, which consequently dropped down to a shapeleas mass." (23)

The final account for the McFarland contract (below) details the large amount of excavation and embankment needed to prepare a foundation, and possibly shore up the adjacent bank, and the substantial quantities of wood required to build the superstructure:

Side chopping, Grubbing and Cleaning			$ 30.00
___, Bailing and Draining			75.00
Earth excavation	2,273.22	cubic yds.	340.98
Embankment	3,124.20	" "	437.39
Puddling earth	794.66	" "	158.93
Procuring & puddling gravel	153.22	" "	61.29
Loose stone	144.00	" "	144.00
White oak timber	11,789.	board feet	471.56
White pine timber & plank	47,488.	" "	1662.08
Hemlock timber & plank	19,353	" "	309.65
Chestnut timber & plank	9,112	" "	318.92
Wrought iron	659	pounds	65.90
Cast iron	800	"	64.00
Spikes & nails	3,420	"	273.60
Total minus deduction for state materials			4385.30 (24)

The sluices at five of the other locks on the Feeder (Locks 2 and 3,4,5 and 12) were not rebuilt until nine years later. The final account for a contract let to Benjamin Wells in August 1867, lists costs for the excavation of "old masonry" and "taking up and relaying vertical wall," both dry and in cement (mortared), implying repair of the old stone sluice and discharge baain, and possibly the adjacent retaining wall, prior to construction of a wooden superstructure (assuming that these were comparable to the five combined sluice in design). (25)

The worsening condition of the sluice around the five combined locks over the period 1868-74, documented in annual canal commissioners reports and reports of the state engineer and surveyor, culminated in the construction of a completely new sluice in 1875-6. This structure continued the use of a wooden trunk above the old stone sluice, as indicated in the canal commissioners report of 1876: "A new sluice around the five combined locks on the Glens Falls Feeder is being rebuilt, the foundation for the trunk has been completed and a part of the woodwork..." (26) As discuased on the following page, the design of this structure was apparently different from that of the previous sluice.

The designs used in the sluices built in 1858-9 and 1875-6 csn be understood both from statements msde in annual canal reports, and from construction plans which, though undated, can be attributed to these structures. It is probable that the plsn of the "Sluiceway at Combined Locks Glens Falls Feeder" (NY-200-22), the first of two undsted plans to be discussed, depicts the structure built around the five combined in 1858-9. In this design, a steeply pitched wooden trough is shown supported on sets of wooden posts driven into an esrthen base. This type of sluice would seem to correspond to the precarious structure discussed in the 1868 report of the ststе engineer: "The wooden sluice around the five combined locks on the Glens Falls Feeder must be rebuilt this winter, as much difficulty and risk hsve been encountered in **making it stand** during the season." (27) A statement made by a locsl cansl superintendent in 1880, in reference to the combined sluice at Locks 2 and 3 (which stood at least until 1883), (28) describes this structure ss "dangerous, standing as it does **upon stilts over the old and decayed arch.**" (29) This is a more definite reference to the type of structure shown in the plan. It is very possible that the legged sluice at Locks 2 snd 3 copied an earlier design used at the five combined.

The post-supported sluice design was apparently a forerunner to s stepped, pier-supported design used at the five combined for three different structures, which are shown in the following documents: the undated "Plan of Proposed Sluice around 5 Combined Locks Glens Fslls Feeder" (NY-200-23), the plan for a sluice built in 1889-90, "Plan and Profile for Sluice sround 5 Combined Locks, Glens Falls Feeder," (NY-200-24), and sn undsted photograph of a structure built c.1903 (NY-200-17, Grayer collection). One considerstion in the design of an enduring structure would have been the foundstion. A progression to a more secure support system at the sluice around the five combined is shown by the use, in (inferred) order, of wooden legs (NY-200-22: 1858-9?), stone piers (NY-200-23 and 24: 1875-6? and 1889), snd cement piers (NY-200-17 snd field inspection: c.1903?). A second considerstion would hsve been the sluice profile, in which the combination of drops and gradients would be optimized to limit the critical velocity (and potential destructive force) of the water flow. (30) The use of shallow grsdients and numerous, short drops, in theory, would have been preferable to a design using a single, steep grsdient with no drops. A refinement of trough designs, with regard to critical velocity, is thus implied in the following (inferred) order of use at the five combined: one 15% grsdient, no drops (NY-200-22: 1859-9?); five 3.5-5.2% gradients, four 5-foot drops, (NY-200-23: 1875-6?); five 2.5-4.5% gradients, four 4.5-foot drops, (NY-200-24: 1889); exact measurement unknown, but very similar to NY-200-24 (NY-200-17, field inspection: c.1903?). (This progression is taken one step further in the Barge Canal sluice, which used fifteen, 3-foot drops and level gradients). A reduction in the cross-section of the sluice trough, from 36 squsre feet in the probable 1858-9 structure, to 25 square feet in the three subsequent structures, representing a 30% reduction in water capacity, may have been viewed as a further necessity for the preservstion of the sluice trough.

It is interesting to note that with reference to critical water velocity the stone arch sluice combined the worst and best components; the five 10-foot drops, mirroring drops in the adjacent locks, would have accelerated the flow excessively, and the level sections would have counteracted this effect. The profile of the 1858-9 sluice, in its radically different design, could have reflected a conscious rejection of the failed previous design.

The first use of the stepped, pier-supported design at the five combined, as suggested, would have been for the 1875-6 sluice, depicted in the second undated plan (NY-200-23). In this plan, the profile drawing for the support piers seems to depict the use of a cement cap over the stone arch sluice, but actually is showing the outline of a stone pier. (The use of structural cement for the Glens Falls Feeder and other state canals appsrently did not begin until after c.1900). (31) This use of stone construction is implied in the profile for the succeeding 1889 sluice, which by noting "Piers to be repaired when necessary," alludes to the previous use of stone support piers. Remnants of stone piers which may belong to this sluice are extant in two locations; one at 65 feet down from the second drop (NY-200-5, STONE SLUICE, HEAD OF 40-FOOT BREAK), and one at 10 feet down from the third drop (NY-200-6, STONE SLUICE, BEGINNING OF LOWER STANDING SECTION). They are of mortared stone construction, in the first case apparently using the lower section of s previously collapsed arch wall as a base, and in the second case, built over a standing section of the arch. The two piers are separated by a distance of about 44 feet, not an even multiple of the 12 foot interval depicted on the plan. This deviation could suggest that the piers belong to the 1889 sluice instead, which as indicated below, planned for piers 22 feet apart.

Other components of the sluice built in 1875-6 were a "crib constructed and filled with stone between the head of the locks and bulkhead, and 100 foot lineal wall, in cement (mortared), on berme bank, to protect the same, and an apron loaded with stone at the foot of the sluice." (32) The use of a stone apron for the discharge basin may have repeated a basic design employed in the previous two sluice structures, as indicated in the (probable) plan for the 1858-9 sluice (NY-200-22), which proposes a new apron and shows the previous crib and stone apron, of which the "old stone (was) not to be removed."

Deterioration of the 1875 sluice around the five combined, like previous sluice structures built here, snd at the other locks on the Glens Falls Feeder, was rapid. This is shown in annual reports of the state engineer and surveyor, and the superintendent of public works beginning in 1883, which call for a new trunk and further reconstruction at the five combined.

In 1889, construction of a new sluice was begun at the five combined, under a contract let to Daniel Sturtevant of Sandy Hill (Hudson Falls). As shown on the "Plan and Profile for Sluice around 5 Combined Locks Glens Falls Feeder" (NY-200-24), the proposed sluice was similar in design to the previous structure, having a wooden trunk with four drops (five including the drop into the discharge basin-not shown), supported on stone piers above the stone arch sluice. The principle differences between the 1875-6 and 1889-90 structures, as discerned from the respective plans, are that as indicated previously, the gradient of the new trough is slightly shallower, with shorter drops, and the new piers are shown spaced 22 feet apart, and in cross section taper upward. As indicated, the new structure apparently planned on reuse of the piers of the 1875-6 structure (which were "to be repaired when necessary").

The spillway for the 1889 sluice is depicted in the "Plan of Discharge Basin at End of the Sluice Way around Locks 6 to 10 on the Glens Falls Feeder" (NY-200-25), which shows stone pavement laid over a timber and loose stone/gravel base. The elevation drawing for this structure shows that construction of a new north sidewall would require removal of a portion of the old wall near the head of the structure, and slight raising of this wall further downstream. The proposed south sidewall would meet the existing wall approximately ten feet further upstream. In addition, a one-foot wide batter wall would be built against the stone walls.

The junction of the old and new sections of the north sidewall is shown in a present view (NY-200-13, DISCHARGE BASIN, NORTH SIDEWALL); the 1889-90 construction is built of smaller, more irregular stones than the old, probably 1841-2 ashlar construction. The north sidewall continues partially intact to near the confluence of the sluice with the Feeder channel below Lock 6, and as shown by comparison of a current view (NY-200-15, VIEW NORTHWEST, DISCHARGE BASIN) with a 1912 view of the sluice (NY-200-19, VIEW NORTHWEST, BARGE CANAL SLUICE AROUND FIVE COMBINED, UNDER CONSTRUCTION), has been substantially buried by waterborne sediment. A current view of a remaining section of the old south wall shows some evidence of tampering near the top of the construction, possibly indicating that this wall too was raised (NY-200-14, DISCHARGE BASIN, SOUTH SIDEWALL). The 1889 wall proposed upstream from this section is non-extant.

The final account for the Sturtevant contract (page 11) details the labor and materials required for construction of the 1889 sluice. Note the smaller amounts of excavation and embankment required for this structure compared with the 1858 structure. This may be indicative of the less radical change in design from 1875 to 1889 than from 1841 to 1858, if the previous assumptions about design are correct. The smaller amount of timber needed in the 1889 structure would correspond partly to the use of masonry piers and a smaller sluice trough.

Removing old sluiceway			$ 100.00
Bailing and Draining			25.00
Blocking under Drops			28.23
Excavation of Earth	183	cubic yds.	73.20
Embankment	379	" "	189.50
Vertical Wall in Cement	163.2	" "	816.00
Paving	35.5	" "	142.00
Loose stone	27.0	" "	27.00
Gravel Filling	40.0	" "	20.00
White oak timber & plank	14,739.	bosrd feet	589.56
White pine timber & plank	42,468.	" "	1167.87
Hemlock timber & plank	4,964.	" "	309.65
Wrought iron	194	pounds	9.70
Spikes & nails	1,965	"	98.25
Total minus deduction for vertical wall stone provided by stste			$3298.75 (33)

A separate contract was let to Daniel Sturtevant in December 1889, for reconstruction of "110 feet of vertical (retsining) wall, between the locks and sluiceway and repair (of) foundations of other portions of (the retaining) wall." The final account for this work is shown below.

Underpinning old wall			$ 6.60
Excavation of Earth	653	cubic yds.	261.20
Embankment	785	" "	235.50
Vertical Wall in Cement	145.9	" "	729.50
Hemlock timber & plank	17.5	board feet	59.50
Spikes & nails	100.0	pounds	5.00
Total minus deduction for vertical wall stone provided by state			$1253.50 (34)

Like its precedecessors, the 1889 sluice around the five combined was short-lived, requiring "repairs" as soon as 1892. (35) A failing wood bottom reported in 1896 (36) was replaced in 1898 (collapsing piers were not replaced), when the sluice was "otherwise straightened." (37) Additional repairs in 1901 included relaying of the stone pavement in the discharge basin in Portland cement. (38) Evidence of this, or later construction is shown in two current views of the discharge basin (NY-200-12, VIEW NORTHWEST, DISCHARGE BASIN; NY-200-16, DISCHARGE BASIN, FLOOR). The three cement crossbars poured on ashlsr and loose stone foundations, appear either to have supported a timber floor, or to have been used to create turbulence in order to help slow the velocity of water spilling out of the sluice, before it re-entered the Feeder channel.

In 1903, further improvements on the sluice around the five combined were completed. One statement in the report of the superintendent of public works for 1903 describes this work as "repairing sluices along berme side of Locks 6 to 10..," listed at a cost of $274.00. (39) Another statement in the same report indicates that "new sluices" were built around the five combined, (40) implying more than the listed cost of reconstruction. An undated view, probably taken around the turn of the century (NY-200-17, Grayer collection), shows that a stepped sluice, possibly built c.1903, had replaced the previous wooden trunk above the stone arch. The photograph shows that this sluice was built partially of cement and partially of wood.

The row of concrete piers extant along the top of the stone arch sluice, over its entire length, apparently belong to the photographed sluice. (no other reconstruction of the sluice around the five combined after 1889-90 is known prior to the Barge Canal era). The piers consist of one large platform built on top of the second drop, and a series of 21 smaller piers, two feet in width, absent only in the 40-foot collapsed section of the stone arch (NY-200-4, STONE SLUICE, TOP OF UPPER STANDING SECTION; NY-200-5, STONE SLUICE, HEAD OF 40-FOOT BREAK; NY-200-8, STONE SLUICE, TOP OF LOWER STANDING SECTION). The piers are spaced 11-13 feet apart at four levels corresponding to the drops in the supporting stone arch sluice, and apparently utilized a lengthwise slot in the top, in which the cross-members for the wooden trough fit (NY-200-8, STONE SLUICE, TOP OF LOWER STANDING SECTION). This data indicates that the basic design of the sluice was comparable to that of the two previous structures.

It was not determined whether the sluice shown in the undated view (Grayer collection) corresponds to the "new sluice" implied in the 1903 report. The apparent use of Portland cement for structural components does, however, help establish its date of construction. Development of the Portland cement industry in New York and adjacent areaa commenced in the early-mid 1890's, at which time five plants began operation (notably including the Glens Falls Portland Cement Company, built in 1894). (41) The advantages in cost and efficiency inherent in the use of cement in general, was recognized by the office of the state engineer, which in 1897-1900, requested that both Portland and natural hydraulic cements be tested for possible use on canal improvements. The testing showed that the Portland cements in all but one case showed greater strength, and presumably, this was the material of choice for most purposes. (42) It should be noted that natural rock cement had already been in use for lining walls and floors of canal structures for at least thirty years.

Construction of the sluice shown in the undated view (Grayer collection) thus would have occurred at a time after the described testing, or c.1900. The latest possible construction date can be inferred from a statment in the report of the superintendent of public works, which in 1906, already refers to a new footbridge across the sluice at Lock 10. (43) The use of footbridges for the c.1903 sluice is shown in the undated view (Grayer collection). The reference cannot apply to the earlier, 1889 sluice, the design of which would have precluded its use to support a footbridge.

In 1903, the Glens Falls Feeder became part of the Barge Canal system, created under Chapter 147, Laws of 1903 for the enlargement and overall improvement of the Erie, Oswego and Champlain Canals. The improvements proposed for the Glens Falls Feeder were to enhance its function as a water source for the Champlain Canal. As a navigational route, the Feeder had only benefitted from one of the previous Champlain enlargements, and consequently, could only accomodate boats of 140-ton capacity, substantially smaller than the norm for the canal system at the turn of the century. Complete reconstruction of the Feeder channel for navigation was not considered justified due to state policies then affecting industrial development in the upper Hudson region. (44)

Work upon the Feeder was initiated in 1912 under Contract 56 of the Barge Canal legislation, (45) by Flood and Van Wirt Co. (46). Replacement of the bypass sluices was included within this contract. As shown in the plan for the sluice around the five combined (NY-200-26, "Contract No. 56, Details of By Pass, Locks 6-10), the Barge Canal structure was built in-ground, to the adjacent south of the stone sluice alignment, and consisted of s (Second Class) concrete trough, 16 feet in width and four feet in depth, using a combination of fifteen 3-foot drops and level gradients. The sluice began at a headwall with four 2 x 3-foot gates and returned to the earlier discharge basin via a concrete wingwall which abutted the old north sidewall. Presently, the structure consists of a largely undermined and collapsed upper section (NY-200-1, DESTROYED HEAD OF SLUICE, NY-200-8, STONE SLUICE, TOP OF LOWER STANDING SECTION), and a largely intact lower section, about 240 feet in length (NY-200-11, BARGE CANAL SPILLWAY).

The Glens Falls Feeder ceased operation as a navigational canal in the mid-1920's (annual canal reports). The closed locks are shown in a subsequent view (NY-200-18, Brown notebook). The Barge Canal sluice continued to channel water into the Glens Falls Feeder until the early 1970's, when the upper portion of the structure was undermined and collspsed. (47) The Feeder presently still supplies the Champlain summit; it is interesting to note that as in 1834, the use of the five combined locks themselves to channel water has resulted in excessive deterioration of these structures, and has drawn attention to the need for a new bypass structure.

In concluding the history and description of the Glens Falls Feeder: Sluice two adjacent features or groups of features related to its operation warrant discussion. These consist of a retaining wall built to support the bank directly adjacent to the upper portion of the sluice, and the retaining walls for each of the five lockkeepers platforms.

The retaining wall consists of a 230-foot section from the second drop to a location 20 feet down from the third drop. It is constructed of dry-laid limestone slabs and blocks suggestive of early canal construction. As indicated previously, under the contract let to Daniel Sturtevant in 1889, a 110-foot portion of this wall was reconstructed "in cement," or mortared stone. No evidence of mortared construction is extant, suggesting that the

Sturtevant work may have been for sections removed and later encased in cement near the head of the sluice. The present condition of the wall is as follows from its west end: 0-30 feet - encased in cement, 30-70 feet - partially deteriorated, 70-110 feet - collapsed above the break in the stone arch, 110-230 feet - substantially intact (NY-200-4, STONE SLUICE, TOP OF UPPER STANDING SECTION; NY-200-5, STONE SLUICE, HEAD OF 40-FOOT BREAK; NY-200-8, STONE SLUICE, TOP OF LOWER STANDING SECTION).

The retaining walls for the lockkeepers platforms demonstrate dry-laid limestone block and slab construction, built at an unknown phase of canal improvement. The cement caps may be contemporary with either the c.1903 or 1912 sluice reconstructions. Due to the loose stone construction of the walls, it is probable that repairs were frequent over time; the use of more rubbley construction in some of the walls may represent reconstruction. In all cases, the retaining walls have failed at the apex of the turn required to support two sides of the lockkeepers platform, and in most cases, in the sections built parallel to the bank. The principal exception is at Lock 8, which may have been partially rebuilt (NY-200-9, 10, LOCK 9 RETAINING WALL SOUTHEAST FACE, AND NORTH VIEW). The undated view (NY-200-17, Grayer collection) and the 1912 Barge Canal views (NY-200-19, 20) depict the walls in good condition. A later 20th century view shows major deterioration of the wall at Lock 8 (NY-200-18, Augusta Brown notebook).

While the described features were not sctually part of the sluice itself, their presence would have helped to ensure preservation of the various sluice structures over time by restricting the collapse of the adjacent bank(s) downslope. As shown on the Site Plan for the Glens Falls Feeder (GFFS Drawing-2), the gradient of the bank where the retaining walls were built is approximately 40% (10 feet vertical: 25 feet horizontal). Excavation for the stone arch sluice in 1841-2 would have destabilized this bank by removing its toe, thus necessitating artificial support (walls) to prevent slumping. Presumably, the collapse of soil onto the stone arch sluice would not have been desirable, adding additional weight on top of an already unstable structure, and potentially in-filling the discharge basin. This scenario may well have been more important for the survival of subsequent sluice constructions, which as noted, were built precariously above-ground using the stone arch sluice as a base. The described contract for upgrading the retaining wall in 1889, concurrent with the construction of a new sluice structure, demonstrates inclusion of the adjacent bank as an integral component in the proper functioning of the sluice.

The significance of the Glens Falls Feeder: Sluice is twofold. First, the Glens Falls Feeder: Sluice represents an exceptional engineering structure, relative to other bypass structures built on canals in New York State. This importance applies most directly to the 1841-2 stone arch sluice, the first successful sluice built around the five combined locks (the original wooden sluice only lasted two years), and the structure most closely identified with the early use of the Glens Falls Feeder. A substantial portion of the (repaired) stone arch structure is extant, and as discussed, can demonstrate important aspects of the original construction technology and operation of the sluice.

The stone arch sluice can be considered unusual due to the combined factors of sbsolute length, snd construction technology. An inspection of the available records for other canals in the New York State system has shown that in no other instance were five locks built in combination. The Erie Canal utilized a four-lock combine at Lockport, and single and double locks elsewhere. (48) The Black River Canal, perhaps overall the most comparable to the Glena Falls Feeder, providing navigational access into an upland ares and functioning as a feeder (to the Erie Canal), descended relatively quickly over its upper section; between Locks 71-107, three four-lock combines snd three triple locks were used in close succession. (49)

The Lockport and Black River structures demonstrated the use of their own types of sluice construction. At Lockport, the original bypass is shown as a small, stone box culvert; the later bypass system consisted of both a millrace and a separate culvert, the culvert a larger square structure built of timber and possibly stone (profile is unclesr). (50) On the Black River Cansl, the bypass for a single lock (Locks 1-70 and Lock 102 - built c.1850), is shown ss an open structure with stone sidewalls and lining, using one, approximately 5% gradient. (51) A profile drawing for combined Locks 99-101 depicts the use of ten shallow drops (2-5.5 feet), and probably level gradients to descend a total of 35.5 feet. (52) Although the structure for this sluice is not shown, and perhaps because it is not shown, the sluice for Locks 99-101, probably conformed to the open spillway design shown for the single locks.

Apparently then, the circumstances requiring a structure of comparable length to the sluice around the five combined would have been rare, at least in New York State. And as indicated, in the few documented instances where a greater than double lock combination existed, the bypass structure was dissimilar to that at the five combined. It is quite possible that the buried stone arch design was employed for sluices only on the Glens Falls Feeder, where other than the five combined, only one other combination was utilized, for Locks 2 and 3. The instability of the earlier stone arch sluice, perhaps the preference of a local engineer, may well have made others hesitant to copy its design. It is significant that many of the other sluice structures built in 1841-2 on the Glens Falls Feeder were directly impacted by Barge Canal construction in 1912-15, and where extant, have suffered from deterioration.

The Glens Falls Feeder: Sluice also derives significance aa a component of the Glens Falls Feeder, shown by previous studies to be historically important "as a transportation and engineering feature which greatly contributed to the economic development of Glens Falls and the upper Hudson-Southern Adirondack Region." (53) From its completion in 1828, through the 19th century to the present, the Glens Falls Feeder has been of continued importance in its original role aa a feeder canal, helping to ensure uninterrupted transportation on the Champlain Canal. The Champlain Canal was one of two principal lateral canals in the New York State system, connecting the Hudson River at Waterford with Lake Champlain at Whitehall, and providing a direct link for the shipment of raw materials extracted in northern parts of

New York and Canada to southern markets. (The success of the Champlain, Erie and other canals in the state would facilitate the development of New York City into a thriving port in the mid-19th century, at the expense of both Boston and Philadelphia). Use of the Champlain Canal by the larger commercial vessels which navigated the Erie Canal was initially restricted in the mid-late 19th century due to the piecemeal enlargement of the original locks and canal prism. A primary reason for this scenario was the continued diffusion of funds into maintenence of the Glens Falls Feeder (which had frequent leaks and structural failures), indicative of the importance of the feeder as a component of the Champlain system. (54) As discussed, the operatiion of bypass sluices around navigational locks on the Feeder were instrumental to the provision of an adequate water supply downstream.

As a navigational canal, beginning in 1832, the Glens Falls Feeder had a direct impact upon the development of Glens Falls and Sandy Hill (Hudson Falls), settlements which were located along its seven-mile course, as well as the encompassing upper Hudson area. The growth of the lumber, lime and black marble industries, and related businesses, was especially marked after 1845, when enlargement of the Feeder to accomodate two vessels broadside permitted a significantly increased flow of commercial traffic to and from the Champlain Canal. (55) Timber from the Adirondack Mountains was floated down the Hudson River to Glens Falls, processed in sawmills along and near the Feeder, and shipped south. Lumber production remained the principal industry in Warren County through the late 19th century, taking a lesser role in the 20th century as northern forests began to wane. (56) The lime industry exploited extensive and pure limestone deposits in Glens Falls profitably for about one hundred years beginning in 1834. The success of this industry depended on a symbiosis with the lumber industry; waste wood from the sawmills provided a cheap supply of fuel for the calcination of limestone. (57) Consequently, as the lumber industry faltered in the early 20th century, so did the the lime industry. The black marble mines in Glens Falls were the only commercial source of this material until the early 20th century, when the appearence of lower priced European marbles on the market resulted in the termination of local production. (58)

The Glens Falls Feeder was instrumental in the continued success of the preceding industries despite the fact that unlike the Champlain Canal itself (after 1876), the Erie and other canals in the state system, the Feeder was never enlarged a second time, and could only accomodate 140-ton boats. When in 1914, the Glens Falls Feeder was included in a bill for the enlargement of four small lateral canals which in 1903 had come under the Barge Canal umbrella, uncertainties were voiced about the future of economic development in the upper Hudson region, based on questions of potential state involvement in Adirondack reforestation (for timber) and in the management of the upper Hudson as a continued source of water power. (59) As result, the Feeder was not improved and would operate as a navigational canal only for another 15 years.

It is important to point out that as sn embodiment of the significsnce inherent in the Glens Falls Feeder, the Glens Fslls Feeder: Sluice, must be viewed as the more inclusive group of components based around the stone arch structure alresdy discussed. These components represent features of subsequent sluices which incorporated the 1841-2 structure for use both in its originsl cspacity (discharge basin) and for adaptive reuse as s foundation (culvert section), and which eventually bypassed the stone sluice altogether. Also included are the associated stone retaining walls, which were necessary components of the sluice/lock site. Although of the sluice structures, it is primarily the final two rebuilding phases which are represented (c.1903 and 1912), close examination of the site can reveal generally how the sluice structure evolved over its first 75 years of use. The progression of sluice construction at the five combined is closely linked with the development of the Glens Falls Feeder and its impact upon the locality and the region.

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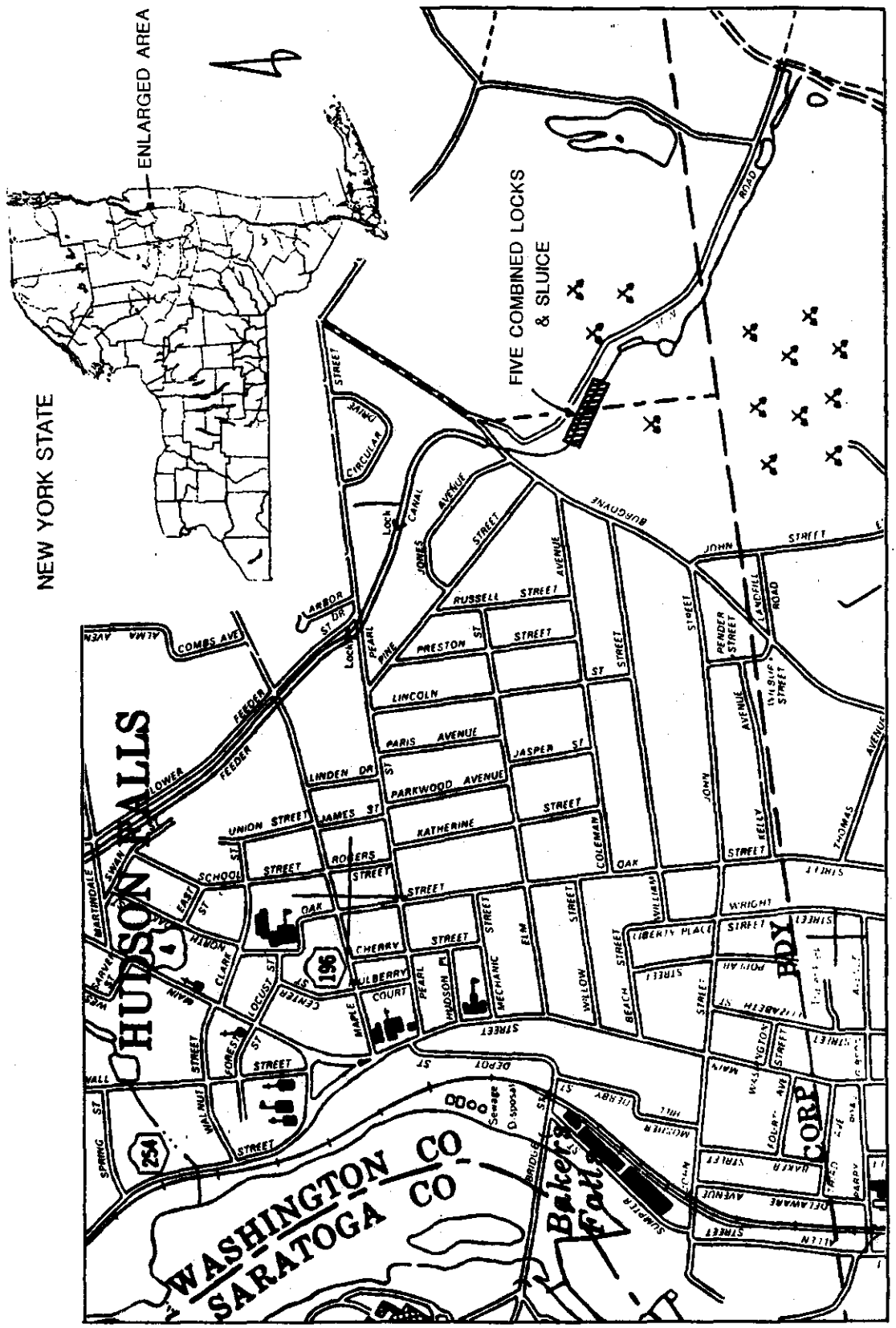

GFFS DRAWING-1. Locational Map of Glens Falls Feeder five combined locks and sluice
(N Y S Department of Transportation, Hudson Falls 7.5' quadrangle)

SCALE = 1 inch: 1100 feet